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Possible explanations for the decline in the Eurasian Golden Oriole (*Oriolus oriolus*) in the United Kingdom

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ABSTRACT

Eurasian Golden Oriole (*Oriolus oriolus*) populations have followed a very different trend in the United Kingdom compared to the rest of Europe. This paper looks at the potential causes of this trend: isolated populations due to a decline in the Netherlands; a very specific habitat of hybrid Black Poplar (*Populus nigra*) plantations; a restricted diet due to this habitat; and longer migration distances. It is possible that all of these factors contributed to the rapid decline of Golden Orioles in the UK, as well as a period of slightly wetter, cooler summers from the late 1990s to 2007.

INTRODUCTION

Unlike many other continental-European species such as the Black-winged Stilt (*Himantopus himantopus*) and European Bee-eater (*Merops apiaster*), the Eurasian Golden Oriole (*Oriolus oriolus*) population has declined rapidly in the United Kingdom (UK), despite the effects of climate change. Golden Orioles were first recorded breeding in the UK in the 1830s, and the population has remained relatively small and unstable since then. The population peaked at a maximum of 42 breeding pairs in 1990 (Spencer *et al.*, 1990), before declining from the late 1990s onwards. Between 2008 and 2011, Golden Orioles were only recorded as confirmed breeding in two 10km squares in Britain (Balmer *et al.*, 2013). Eventually, the species was moved to the former breeding birds list in 2015 (RBBP, 2023). This trend in the UK contrasts that of Continental Europe,

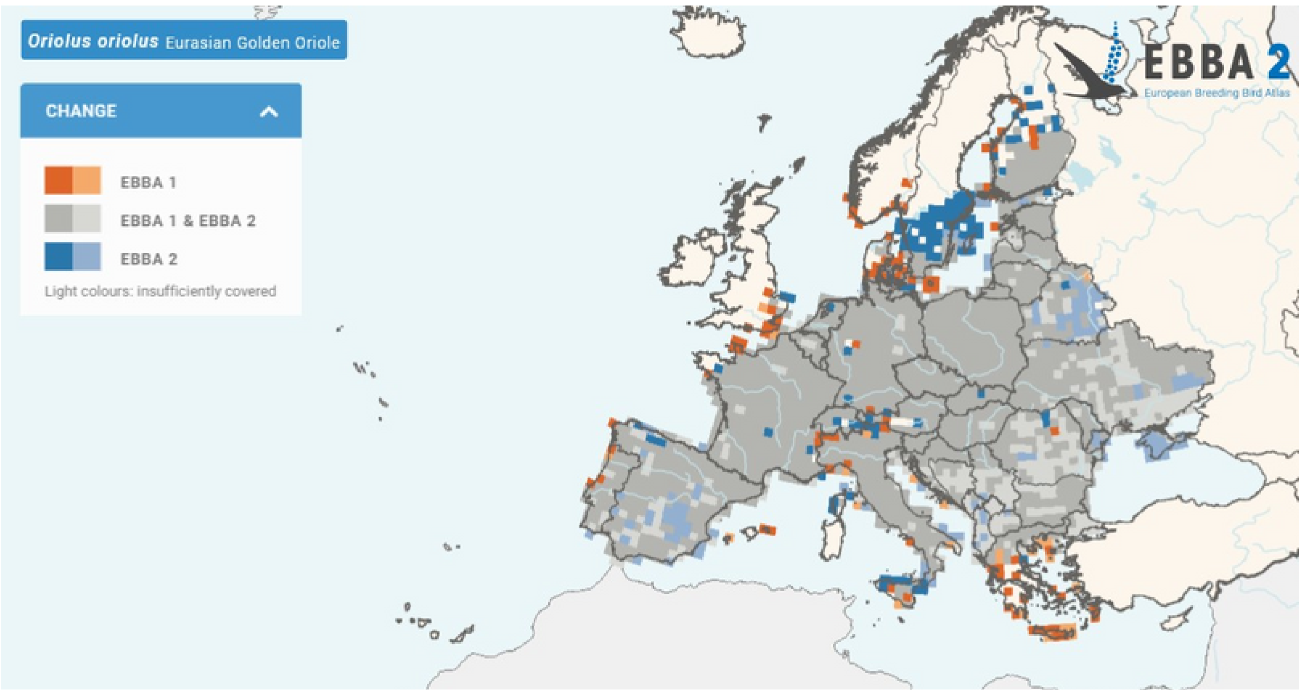

Figure 1 – Population changes in Golden Orioles in Europe from the 1980s (EBBA 1) to 2017 (EBBA 2; EBBA 2 Maps 2023).

where the Golden Oriole has maintained a stable population in many countries, even increasing in southern Finland (Fig. 1; Keller *et al.*, 2020). Golden Orioles in the UK have shown a contrasting pattern to those in Europe, seemingly only nesting in hybrid Black Poplar *(Populus nigra)* trees (Milwright, 1998), mainly planted by Bryant and May, a company that frequently felled the plantations for match production. Golden Orioles in Europe nest in a wider range of tree species, and many stable populations are established in mixed deciduous and even coniferous woodland (Mason & Allsop 2009). Golden Orioles spend winter in central and southern Africa, before migrating to Europe (Animalia, 2023). Nowadays, only a few records occur each year in the UK, with most records being on the east coast due to migratory overshoots from northern Continental Europe. There have been no confirmed records of breeding Golden Orioles in the UK since 2009 (Holling *et al.*, 2009).

METHODS

In 1986, the Golden Oriole Group (GOG) was formed. Members of the GOG visited a total of 136 Golden Oriole nesting sites under licence in the East Anglian fens, and data such as nesting habits, number of fledglings, and the typical diet of the birds was collected and published in a paper by Milwright in 1998. Any data for Golden Orioles in the UK post-1998 has been collected from the Rare Breeding Birds Panel (RBBP). Other data on Golden Orioles such as habitat use and diet in the rest of Europe was collected from the book *The Golden Oriole* written by two of the founding members of GOG (Mason & Allsop, 2009). The data from this book was used alongside the paper by Milwright (1998) and data from the RBBP (1990; 2003; 2011; 2022; 2023) to compare habitat use and diet between Golden Orioles in the UK and continental-European Golden Orioles. All rainfall data was taken from the Met Office (2023), and this data was used in comparison with the Golden Oriole data to draw possible conclusions on the decline of the species in the UK. Data for the Netherlands (Sovon, 2023), was also used in comparison with UK data to link together population trends.

RESULTS

While in Europe Golden Orioles nest in a variety of tree species such as Alder (*Alnus glutinosa*), Belgian Oak (*Quercus robur*), Birch (*Betula pendula*), conifers and even Sweet Gum (*Liquidambar styraciflua*), in the UK, the vast majority of nests were found in hybrid Black Poplar trees (Mason & Allsop, 2009). Out of 136 nests surveyed by GOG, 131 were in Poplars, with the other five nests split among Alder and Apple trees. Furthermore, 128 of these nests were in early-leafing Poplar trees (Milwright, 1998). It is thought that broader-leafed, early-growing Poplars such as 'Beaupre' suited the Golden Orioles best as nests were easily concealed in early June (Fig. 2).

The reason why UK Golden Orioles mostly nested in this very specific Poplar hybrid could be due to migration from a Poplar-nesting population in Flevoland, an area in the centre of the Netherlands, close to the coast (Mason & Allsop, 2009). It is likely that the first birds to appear in the UK may have originated from this population, and were therefore inclined to nest in Poplars. However, why the Dutch population of Golden Orioles originally chose to nest in Poplars is unknown. Possibly, Poplars are used by Golden Orioles as few other species nest in these trees other than corvids, and young birds may prefer to

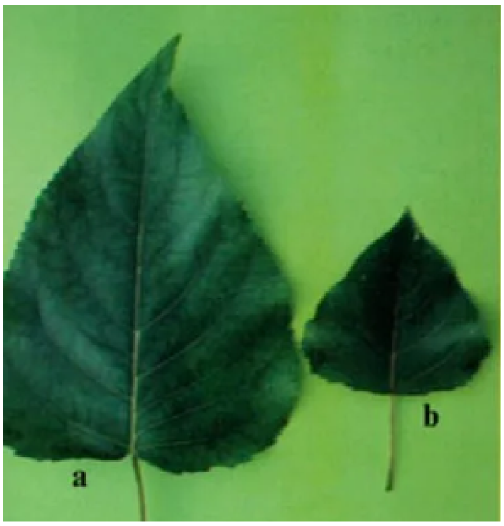

Figure 2 – Beaupre poplar leaf (a) alongside a serotina poplar leaf (b) (Mason & Allsop, 2009).

nest in the same species of tree in which they hatched. If the UK Golden Oriole population did originate from the Netherlands, then the decline in the UK population could potentially be linked to the decline in the Netherlands, which has been linked to habitat loss (BTO, 2023). Golden Orioles in the Netherlands reached a population peak in the late 1980s (when birds first started colonising the UK), before declining until 2015 (the year that the Golden Oriole was officially no longer declared a breeding species in the UK). This could mean that the main cause of decline in the UK could be due to the population becoming more isolated, due to the decline in the Netherlands, rather than from any environmental factors in the UK (Fig. 3–5).

It is also possible that due to the limited variation in nest sites, the poplar-nesting Golden Orioles in the UK had restricted diets, mainly composed of poplar-dwelling species of moth, such as the Poplar Grey Moth (*Subacronicta megacephala*), Poplar Lutestring (*Tethea or*), Hornet Clearwing (*Sesia apiformis*), Figure-of-eighty Moth (*Tethea ocularis*) and White Satin Moth (*Leucoma salicis*). Both the adults and the larvae of these moths were eaten by Golden Orioles in the East Anglian fens, as confirmed by photographs (Milwright, 1998). In total, 15 of the 25 identified prey items were of these species, and a further 28 out of 43 unidentified prey items were Lepidoptera adults or larvae (Table 1).

The restricted diet and habitat of these UK Golden Orioles could have led to the species becoming more vulnerable to extreme weather events. The average first nesting attempt date for Golden Orioles surveyed by the GOG was the 26th of May (Milwright, 1998). In years when temperatures in May were lower than average, Golden Oriole nests in the UK in general had a lower success rate: only two young fledged successfully from a maximum of 11 nests in 2001 (Ogilvie *et al.*, 2001), when temperatures reached a low of 9.6°C, and a high of just 19.9°C in May in Cambridge (Met Office, 2023).

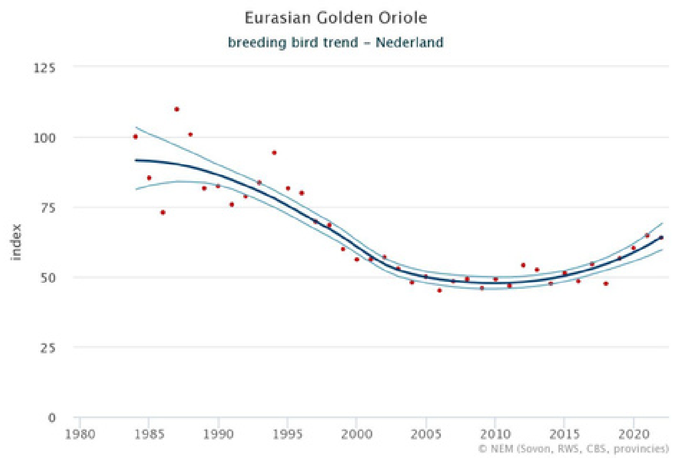

Figure 3 – Changes in Golden Oriole population in the Netherlands from 1980 to 2020 (Sovon website 2023).

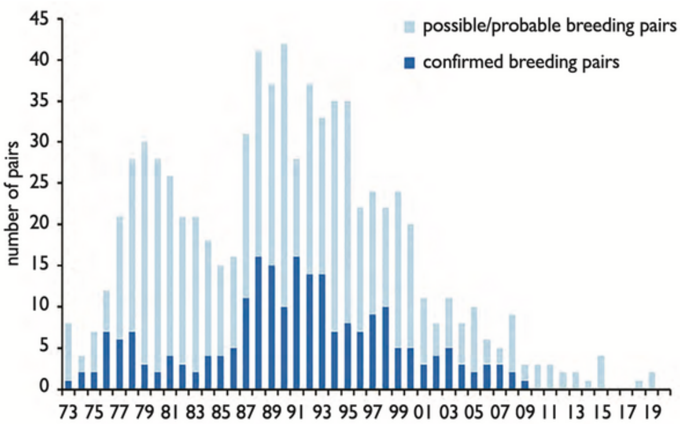

Figure 4 – Numbers of confirmed breeding pairs and possible breeding pairs of Golden Orioles in the UK from 1973 to 2020 (Eaton & RBBP, 2022).

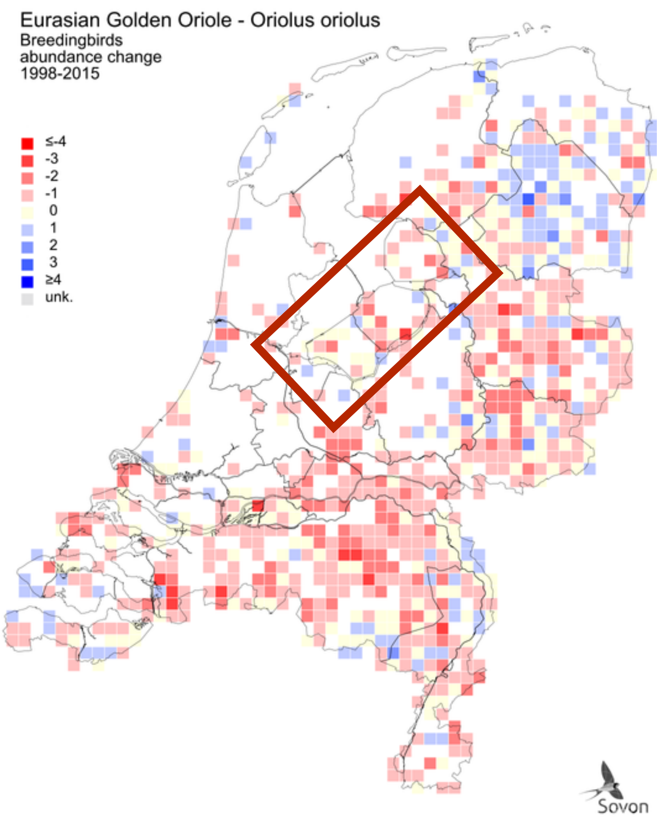

Figure 5 – Change in number of breeding pairs of Golden Oriole in the Netherlands from 1998 to 2015, with Flevoland highlighted in the box (Sovon, 2023).

Prey item	*No. of prey items identified on photographs*	*Percentage of 4 faecal/gut samples containing prey remains*
Coleoptera		
Chafer sp.	1	–
Unidentified	1	25
Hymenoptera		
White-tailed Bumblebee *Bombus leucorum*	5	–
Unidentified *Bombus*	2	75
Lepidoptera adults		
Poplar Grey Moth *Acronicta megacaphala*	4*	–
Poplar Lutestring Moth *Tethea or*	3*	–
Figure-of-80 Moth *Thethea ocularis*	1*	–
Hornet Clearwing Moth *Sesia apiformis*	2*	–
Peppered Moth *Biston betularia*	1**	–
Unidentified	7	25
Lepidoptera larvae		
Mullein Moth *Cuccallia verbasci*	2	–
White Satin Moth *Leucoma salicis*	5*	–
Peppered Moth	1**	–
Peacock Butterfly *Inachis io*	1	–
Unidentified	21	25
Other invertebrates		
Unidentified Hemiptera	–	25
Unidentified Arachnida	1	–
Unidentified invertebrates	10	–
Total	68	–
Total identified to species level	25	–

*Poplar feeding species. **Deciduous tree (including Poplar) feeding species.

Table 1 – Prey items of Golden Orioles, taken from data from the GOG (Milwright, 1998).

The colder weather in May was thought to have delayed early-budding Poplar varieties (Mason & Allsop, 2009). This would have prevented insects from laying eggs on these leaves (and therefore reduced the already-limited food source for the Golden Orioles), as well as reducing the amount of leaf cover (and suitable nesting habitat). This could have increased predation at the start of the breeding period, as well as reducing the amount of food available for chicks to be fed.

Rainfall during summer months (June and July) may also have affected the breeding success rate of UK Golden Orioles. In 1987, rainfall was higher than usual, and 142.1mm of rain fell during June and July in Cambridge. During this period, only seven birds fledged from twelve nests in the East Anglian fens. In contrast, in 1993, only 91.9mm of rain fell during these two months, and 17 birds fledged from only six recorded nests (Milwright, 1998). The effect of rainfall on Golden Orioles could be due to the unusually large reliance that the UK Golden Orioles had on moths. Higher levels of prolonged rainfall could have led to a reduction in day-flying moths, as well as reducing the amount of hunting time Golden Orioles could utilise each day. However, there is insufficient data on population trends between day-flying moths (such as the Hornet Clearwing) as a result of rainfall patterns to support this theory.

Furthermore, between 1999 and 2007 (the main time period during the decline of the Golden Oriole population), average rainfall during June and July each year in Cambridge was 112.92mm. This contrasts with the average of 73.11mm of rainfall in June and July from 1989 to 1998, when

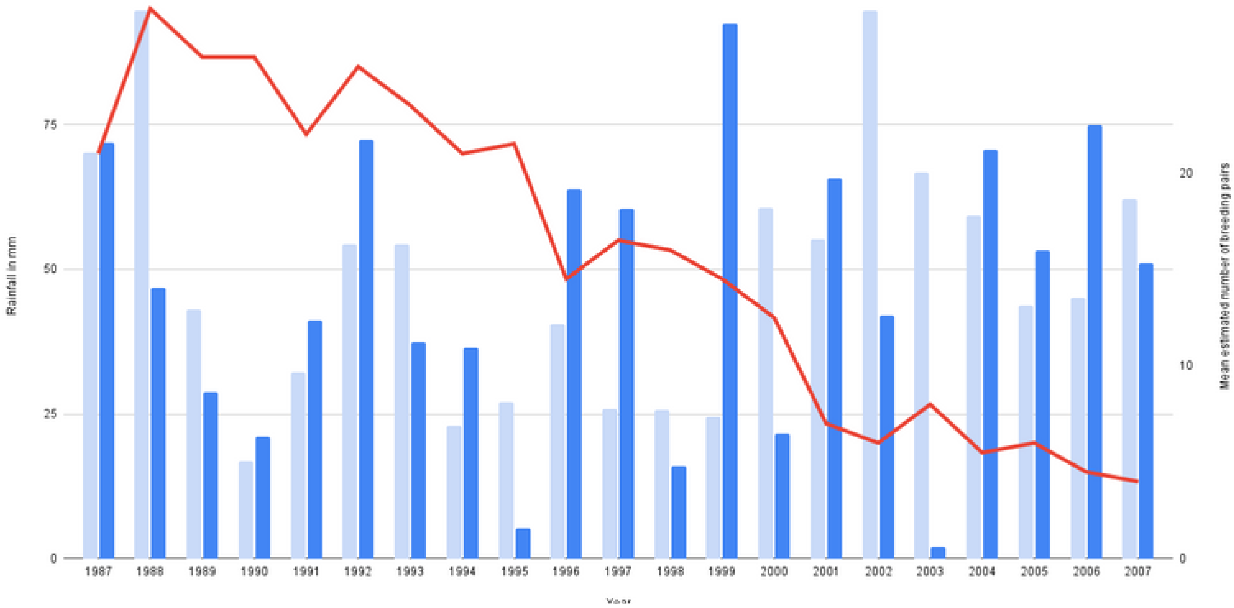

Figure 6 – The mean estimated number of nesting pairs of Golden Orioles in the UK (Eaton & RBBP, 2022) against the average total rainfall from June to July each year (Met Office, 2023). Note that the year after a heavy year of rainfall, nesting pairs of Golden Oriole are normally lower than the year before.

Golden Orioles managed to maintain a relatively stable population in the UK (Fig. 6). This could explain why Golden Orioles are not following the same trends as other Continental-European species in the UK: although climate change is leading to an increase in temperatures during summer months, it is also leading to more extreme weather conditions such as heavy rainfall, which seems to negatively impact the Golden Orioles while providing even more suitable breeding habitat for the likes of Black-winged Stilt and Great White Egret (*Ardea alba*).

The restricted diet and location of the UK Golden Orioles could also have affected the likelihood of second broods, as there are very few records of second broods from the UK (Milwright, 1998). Some species of moth that the birds were seen feeding on such as the Figure-of-eighty moth have a flight period of May to July (UK Moths, 2023). This would mean that by early August, fewer of these moths would have been available for the birds to feed on, which may have limited food sources for second broods. In addition, Golden Orioles first arrived in the UK on average on May 14th; 14 days later than in France and The Netherlands (Milwright, 1998). This extra migration time in spring (Fig. 7–8) may have delayed the first brood of Golden Orioles in the UK, leaving less time for a second brood. In addition to this, Golden Orioles needed to migrate further in autumn in order to reach southern Africa for the

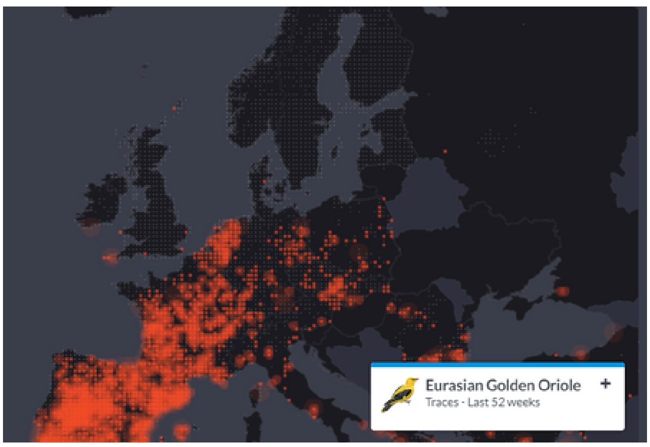

Figure 7 – Reports of Golden Oriole between 30 April and 6 May 2023. By 6 May 2023, Golden Orioles have not reached the UK or Finland (EuroBirdPortal, 2023).

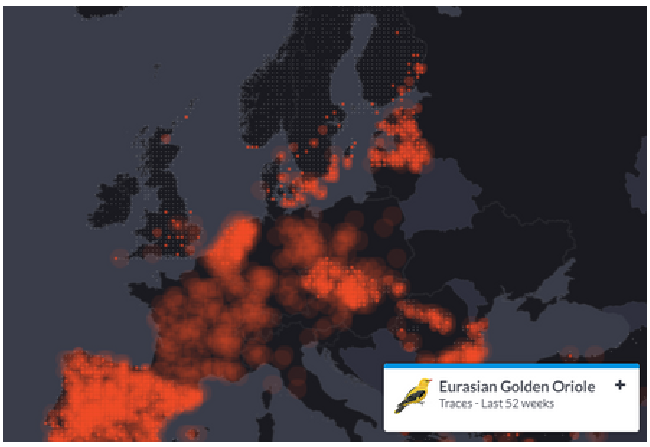

Figure 8 – Golden Orioles have reached Finland, Sweden and the UK by 27 May 2023 (EuroBirdPortal, 2023).

winter. This could have caused the birds to leave the UK earlier in the year compared to those in Continental Europe.

In contrast, mixed woodland has a wider variety of tree species than a man-made, non-self-sustaining Poplar plantation. In woodland containing evergreen trees such as conifers, suitable nesting habitat is not affected as much by cooler temperatures, as leaves are green year-round, helping to disguise nests in May, when some deciduous tree species such as the Poplar may not have developed leaves yet (if temperatures are too cold). This could explain the stability of Golden Oriole populations in southern Russia (Mason & Allsop, 2009), as well as the rapid population increase in southern Finland, where evergreen trees are abundant. This could explain why the average number of fledglings per nest in the UK, surveyed by the GOG between 1976 and 1996, was only 2.15 (Milwright, 1998), lower than the average of 2.5 in Russia (Milwright, 1998), although only 11 nests and 14 nests were studied respectively.

A wider variety of tree species also leads to a wider variety of insects and other potential prey items. This means that Golden Orioles in Europe may be less reliant on day-flying moths, and therefore less affected by heavy rainfall. Golden Orioles in Europe have been found to have a much wider diet including seeds, fruits, spiders and invertebrates as well as moths and butterflies. In some parts of the range, Golden Orioles have been found to feed their chicks with Mulberry (*Morus alba)* fruit (Mason & Allsop, 2009), which would be more abundant in years of heavy rainfall, helping to counteract the decline in other food sources in these years. Mulberry trees are not abundant in the UK, so this could not have been used as a solution to the wetter summers between 1999 and 2007, when the species declined most quickly.

The varied diet of Golden Orioles in Europe could also allow the birds to have a second brood, as food is available for longer periods of the year. In August, for example, when the flight period for Figure-of-eighty moths has ended, Golden Orioles nesting in mixed woodland would have more alternative food sources than those nesting in Poplar plantations. Furthermore, countries in Continental Europe are closer to sub-saharan Africa (where Golden Orioles winter). Therefore, migration time is shorter, potentially allowing continental-european birds more time for a second brood.

CONCLUSION

In conclusion, there are several factors that could have contributed to the decline in Golden Orioles in the United Kingdom. The fact that Golden Orioles in the UK preferred to only nest in Poplar plantations most likely hindered the survival of the species, as this habitat has very little biodiversity compared to the mixed woodland habitat in which the Golden Orioles breed in Europe. This could have enhanced the negative impacts of cold weather and rain on the species. Just like the initial occurrence of the species in the UK, the decline of Golden Orioles could also be linked to the population in the Netherlands. The decline in the Netherlands could

Figure 9 – A mixed woodland Golden Oriole habitat containing Conifer and Birch in Central Siberia (right) in comparison with a typical Golden Oriole Poplar plantation by a river in southern France (left) (Mason & Allsop, 2009).

have led to a more isolated population in the UK, leading to fewer individuals migrating to the UK. It is also possible that Golden Orioles began to migrate shorter distances to allow more time for a second brood.

Since 2015, the population of Golden Orioles in the Netherlands has been steadily increasing, and there is already evidence of Golden Orioles breeding successfully at greater latitudes than in the UK, in southern Finland (Keller *et al.*, 2020). So, based on previous trends in data, we could see another small influx of Golden Orioles in the UK in the near future. However, it is unlikely for the species to develop another self-sustaining breeding population in the UK, unless the species begins to breed in a wider range of woodland habitats. For this type of breeding to occur, it may require birds that have not previously nested in poplars to migrate to the UK, as opposed to poplar-nesting birds from the Netherlands.

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Possible reasons why the Ring-necked Parakeet (*Psittacula krameri*) has successfully colonised the United Kingdom

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ABSTRACT

The Ring-necked Parakeet (Psittacula krameri) is native to Asia and Africa but is now established in over 35 countries. I did a literature review of papers which looked at the possible reasons for why the Ring-necked Parakeet has been such a successful coloniser, looking specifically at the UK. My research suggested that there is no definitive reason for the Ring-necked Parakeet's success but in this paper I explore three possible hypotheses. These are (1) the climate in the UK is a good match to conditions in the species' natural range, giving them a low annual mortality rate and the ability to breed successfully , (2) the lack of predators of adults or nestlings that specialise on Ring-necked Parakeets, and (3) the fact that captive birds were escaping into the wild or being released multiple times during their invasion history.

INTRODUCTION

The Ring-necked Parakeet (*Psittacula krameri*), also known as the Rose-ringed Parakeet, is an emerald green parakeet that is native to Asia and sub-Saharan Africa (GBIF, 2019). The species is now established in over 35 countries across five continents (Menchetti *et al.*, 2016) and since the late 1960s, they have become prominent in many European countries including Germany, the Netherlands, France, Spain, Italy, Greece, Belgium, and the United Kingdom (UK) (Lever, 2005). The species colonised the UK after they were taken from their native range and brought here as exotic pets (Natural History Museum, 2023) and then escaped or were released. There are a number of theories regarding how the birds first entered the natural environment of the United Kingdom but they are now well established and the UK's most abundant naturalised parrot. (Balmer *et al.*, 2013). A definitive conclusion has not been reached for why there has been such an increase in the population, but in this paper I will explore some of the possible reasons for their success. The three hypotheses I explore are: (1) the climate in the UK is a good match to conditions in the species' natural range, allowing them to survive well and to breed, (2) the lack of predators of adults or nestlings that specialise on Ring-necked Parakeets, and (3) the fact that birds were escaping into the wild or being released multiple times during their invasion history.

METHODS

The potential effect climate is having on the success of the Ring-necked Parakeet

I used the BTO's online library catalogue and then with help from Lesley Hindley, BTO Archivist, found the book *Naturalised Parrots of the World* edited by Stephen Pruett Jones (2021). I also looked at the case study named *Global Invasion Success of the Rose-Ringed Parakeet* written by Hazel A.Jackson, looking specifically at the section labelled Growth and Spread. This gave me information regarding how climate is affecting the growth of the population of Ring-necked Parakeets.

I then talked to two scientists at the British Trust for Ornithology (BTO): Dawn Balmer (Head of Surveys) and David Noble (Head & Principal Ecologist). They were able to give me access to papers and information regarding the reason behind the success of the Ring-necked Parakeet. I specifically used the paper titled *Population Biology of the Introduced Rose-Ringed Parakeet* Psittacula krameri *in the UK* (Butler, 2003) and referred to Chapter 3: Factors influencing Rose-ringed Parakeet naturalization probability (p86).

The potential effect that lack of predators is having on the success of the Ring-necked Parakeet

They also helped me to find two papers that mention parakeets and their predators. The first one was *Census of the British Ring-necked Parakeet* Psittacula krameri *population by simultaneous counts of roosts* (Pithon & Dytham, 1999). I specifically looked at p114 which had information about all the factors which have led to the success of the Ring-necked Parakeet. I looked at the information this page had about Ring-necked Parakeets and their (lack of) predators.

The second was titled *The raptor lockdown menu – shifts in prey composition suggest urban peregrine diets are linked to human activities* (Mak *et al.*, 2023)

The potential effect that the gradual introduction of Ring-necked Parakeets over time is having on the success of the Ring-necked Parakeet

Another paper suggested was *Parrots in the London Area- A London Bird Atlas Supplement.* (Arnold *et al.*, 2017). This paper included a graph on page 6 which showed the population change of Ring-necked Parakeets between 1968 and 2013.

RESULTS

The potential effect climate is having on the success of the Ring-necked Parakeet

Growth rate of the population in an area is largely influenced by the climate conditions and there is a much larger growth rate in climate conditions similar to the conditions in the native range of the species (Pruett Jones, 2021; Shwartz *et al.*, 2009). Fig. 1 shows a positive correlation between population growth rates and the predictions of habitat suitability based on climate and niche. (Jackson *et al.*, 2015).

Butler (2003) suggests the Ring-necked Parakeet's native habitats vary from cool and wet conditions

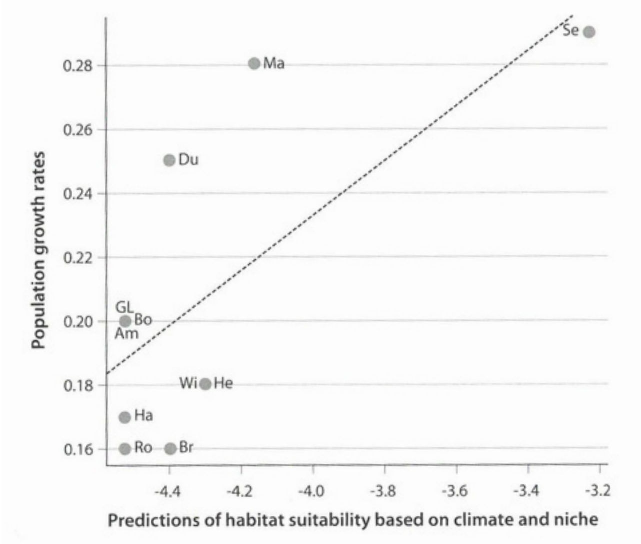

Figure 1 – Positive relationship between Ring-necked Parakeet population growth rates in Europe and predicted habitat suitability in its non-native range (Jackson et al.*, 2015). Am = Amsterdam, Bo = Bonn, Br = Brussels, Du = Düsseldorf, GL = Greater London, Ha = The Hague, He = Heidelberg, Ma = Marseille, Ro = Rotterdam, Se = Seville, Wi = Wiesbaden.*

such as those found in places such as the Himalayas and northern India, and hot and dry conditions such as the savannas of Africa: "climate matching would be of little relevance" to the Ring-necked Parakeet.

The potential effect that lack of predators is having on the success of the Ring-necked Parakeet

Pithon & Dytham (1999) discuss the fact that the Sparrowhawk (*Accipiter nisus*) is the only common predator which is likely to be a threat to the Ring-necked Parakeet. This species is a fairly large parakeet that lives in groups and nests in tree hollows. These characteristics help it to defend itself from many potential predators.

However, Mak *et al.* (2003) also looked at the Peregrine Falcon (*Falco peregrinus*) as a threat to Ring-necked Parakeets. They found that during lockdown, Peregrines were forced to eat more Starlings (*Sturnus vulgaris*) and Ring-necked Parakeets in urban areas, as they had to find alternatives to Feral Pigeons (*Columba livia domestica*), which were leaving urban areas. They concluded that this was because pigeons were not being fed crumbs by people.

The potential effect that the gradual introduction of Ring-necked Parakeets over time is having on its success

London is one of the major areas where Ring-necked Parakeets have settled. Figure 2 shows that this population has increased gradually over time, rather than through a sudden increase.

RESULTS & DISCUSSION

The potential effect climate is having on the success of the Ring-necked Parakeet

There have been varying opinions about whether climate is the main reason for the Parakeets' success. Pruett Jones (2021) proves that the extreme increase of Ring-necked Parakeets is largely influenced by how similar the climate conditions are to the native regions of the species. This species has a very large native range across Africa and Asia and includes areas at higher altitudes which have cooler climates similar to the UK.

However, Butler (2003) states that, as Ring-necked Parakeets have a large tolerance for different climatic conditions and inhabit a large natural range, it is unlikely that moving to areas which have similar conditions to their native regions would have much relevance.

Therefore, as there are differences in opinion about the effects climate is having on the success of the Ring-necked Parakeet, it is only possible to conclude that Ring-necked Parakeets in southern England have not been limited in their growth rate by climate. However, their spread northward to colder parts of the UK, for example, Scotland where there are very small numbers, has been slow and it is not possible to disregard climate, especially during the winter, as a possible influence.

The potential effect that lack of threat from predators is having on the success of the Ring-necked Parakeet

The fact that the Ring-necked Parakeet only has few known predators is an important factor to consider when looking at key reasons for its success. Even the Sparrowhawk doesn't seem to be causing major problems for the Ring-necked Parakeet. The Census of the British Ring-necked Parakeet population by simultaneous counts of roosts (Pithon & Dytham, 1999) shows that

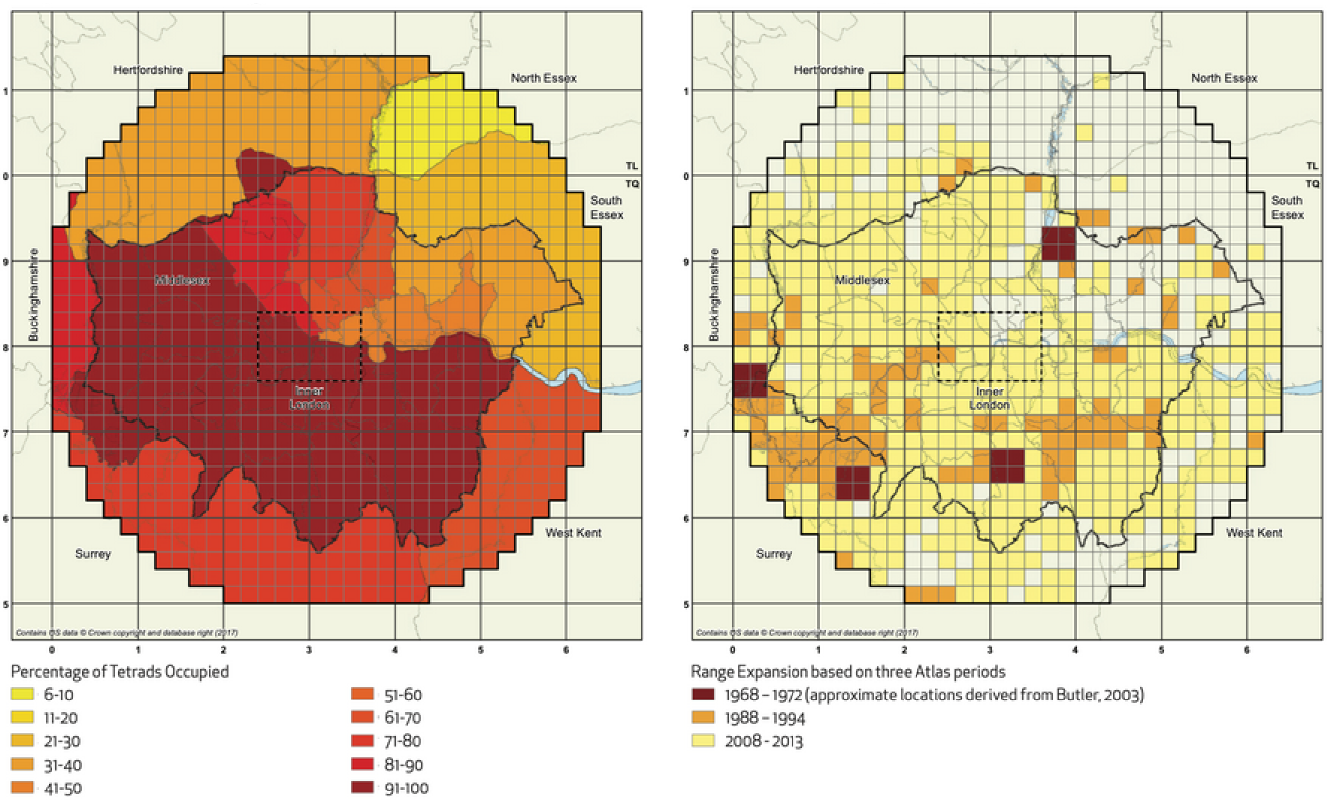

Figure 2 – Ring-necked Parakeets in London, adapted from Arnold et al. *(2017).*

attempts by female Sparrowhawks to take Ring-necked Parakeets have been observed, but no witnessed kills had been reported at the time of publication. However, it also needs to be taken into account that attacks and killings of Ring-necked Parakeets by Sparrowhawks may have just not been reported, so Sparrowhawks can't be discounted as a threat to Ring-necked Parakeets.

Overall, however, the lack of threat from predators does seem a plausible reason for the species' success, but it seems unclear whether this alone would be the main reason. Pithon & Dytham (1999) suggest there could be other reasons, such as the fact that the species nests early.

Peregrines might become a more serious predator of Ring-necked Parakeets in the future. However, it seems likely that this will depend on the availability of Feral Pigeons (Mak *et al.*, 2023).

The potential effect that the gradual introduction of Ring-necked Parakeets over time is having on the success of the Ring-necked Parakeet

A species is more likely to succeed if it is introduced multiple times rather than as a one-off (David Noble, pers comm) which suggests this could be a valid reason for the success of the Ring-necked Parakeet in London. They are popular cage birds in the UK and are kept as pets, as well as in zoos and aviaries. They are known to often escape or even be deliberately released. This means that the population of birds in the wild is constantly being supplied with new birds, which are more likely to survive in the wild if there is an existing population. This is particularly important for Ring-necked Parakeets, which are very social and prefer to forage and breed in groups. However, more research would need to be done comparing areas of the UK to see how the population changed, and to see if evidence could be found to support this hypothesis for the continuing increase in Parakeet populations.

CONCLUSION

To conclude, it seems apparent that more research needs to be done regarding the reasons behind the success of the Ring-necked Parakeet, but the three possible reasons discussed in this paper (climate, lack of threat from predators and gradual introduction) all seem valid possibilities. More research needs to be done and more data needs to be collected in order to prove or disprove them as factors.

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What effects has the reintroduction of White-tailed Eagles had on the south coast of the UK and what is the public's perception of it?

Bertie Harding

ABSTRACT

White-tailed Eagles were driven to extinction in the UK in the early 19th century, and have been reintroduced back into our landscape in multiple locations. The most recent reintroduction has been on the Isle of Wight, in 2019, and a project that was cancelled in Norfolk due to land owners being afraid of the effect the eagles would have on their livestock. I have used Mull as the main example for a successful reintroduction of the White-tailed Eagle. I also looked at the positive effects the birds have had, such as on the eco-tourism in the area, as well as the negative effects, and what local people thought of the project. As well as what conflicts (with sheep farmers for example) might arise. I then looked at methods that could be used to reduce the impacts that farmers might experience on their income. More research is needed into the topic to help this keystone species coexist with humans.

INTRODUCTION

White-tailed Eagles (*Haliaeetus albicilla*) were lost from the UK's landscape in the early 1800s, with the last known pair in 1800 on the Isle of Wight mainly persecuted because of the fear that the birds were eating their livestock (Ashworth, 2021). These are massive birds, with a wingspan of up to 2.4 metres, and have a diet largely of fish, medium-sized mammals, and birds such as Fulmars (*Fulmarus glacialis*). However, these birds are specialists and can adapt to hunt many different sources of food. They will also eat carrion, which is an integral part of their diet when other food sources are in short supply. Since these birds are opportunistic feeders, they sometimes take lambs that are eaten as carrion (RSPB, 2023a). The main case study that will be used in this paper will be the Isle of Mull. They were reintroduced back to the area in the 1980s. Today there are around 100 pairs in Scotland (Forest and Land Scotland, 2020). There is an ongoing reintroduction project on the Isle of Wight, as well as a project that was planned at Wild Ken Hill, but was cancelled. In this paper, I will also look at how the support from the public has changed, and how different groups of people have different opinions on the reintroduction of these iconic birds to the South Coast of England.

METHODS

Most of the research for this paper was conducted online through looking at websites and research papers on the topic of White-tailed Eagle reintroductions. As mentioned, a few examples will be analysed, with the main focus being on the reintroduction of White-tailed Eagles to the Isle of Wight by the Roy Dennis Wildlife Foundation (Dennis, 2023). I have looked at the economic and social benefits of the reintroduction to the Isle of Mull and any other successful projects, and looked at any negative effects these also may have had. The paper will be focused on the opinion of local people, and how different groups might have different opinions on the projects. For this, I found a research paper written by Mike Dunn (2022) about *Public Perceptions on the Reintroduction of White-tailed Eagles to the Isle of Wight and the Solent*, as well as a project that was planned to go ahead in Norfolk's Wild Ken Hill but this was canceled due to land owners objecting (Ashworth, 2021). To look at the economic impact of the eagles on the Isle of Mull, a paper written by Paul Morling (2022) was used.

POSSIBLE BENEFITS

The Isle of Mull is a very good case study for an example of the benefits (and disadvantages) that the reintroduction of a keystone species such as the White-tailed Eagle can have on an area. The birds were reintroduced to Mull back in the 1970s (Forest and Land Scotland, 2020). Morling (2022) identified that the local economy on Mull was greatly affected by the presence of White-tailed Eagles, since between £4.9 and £8 million tourist spend on Mull is attracted by White-tailed Eagles each year; with between 98 and 160 jobs supported by this spend (Morling, 2022). Before the arrival of the birds, the main economies on Mull were farming, fishing and forestry (Britannica, 2018), but these were only replaced by ecotourism after the reintroduction of the White-tailed Eagles. Introducing this species could also be used to highlight the conservation of these places (Dennis, 2023). As a flagship species, White-tailed Eagles not only create ecotourism opportunities, but can also be used to raise awareness for conservation.

POSSIBLE DISADVANTAGES

Although there are benefits to the presence of White-tailed Eagles, there are also people who do not agree with the introduction, due to some disadvantages that they could bring to them. Sheep farmers are worried about the threat that the birds might pose to their income during lambing season. Love (2013) mentions that when they were attempting to release three young birds onto the Isle of Mull, the operation was kept secret because of the prejudice against White-tailed Eagles at the time. “During the project sheep farmers were always its traditional enemies, and its habit of feeding on sheep carrion was enough to seal its fate.” (Love, 2013). In a study funded by Scottish Natural Heritage, it was concluded that lambs only make up a very small proportion of a White-tailed Eagle’s diet(4 to 14%) and that the birds seem to be acting like scavengers, especially when there are lots of still born or non-viable lambs in the afterbirth (BirdGuides, 2010). Some of the authors had seen local White-tailed Eagles on Mull carrying or eating lamb but did not see them catch or kill any of these animals

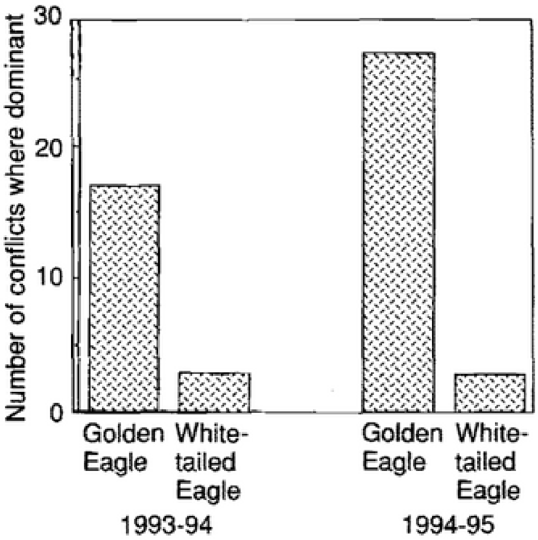

Figure 1 – Dominance relationships between White-tailed and Golden Eagles at carcasses in Norway in Two winters (Halley, 1998).

(Isle of Mull website, 2023).

What is often not talked about is how many lambs are taken by the more adapted and efficient predator, the Golden Eagle (*Aquila chrysaetos*), which did not go extinct in Scotland. There are twice the number of Golden Eagles than White-tailed Eagles on the Isle of Mull (Isle of Mull website, 2023), and since they have a more specialised diet than that of a White-tailed Eagle, it may be more likely that they turn to local lambs during times of lower population of Rabbits (*Oryctolagus cuniculus*) or Mountain Hares (*Lepus timidus*) (Isle of Mull Website, 2023). There was also some conflict between people who were monitoring Golden Eagles, who were worried that the introduction of White-tailed Eagles would put more pressure on the Golden Eagles who were already under pressure from human disturbance. A study by Halley (1998) looked at how the two species interact in Norway, and found that their ranges greatly overlap, especially in coastal landscapes. This shows us that in a healthy area the two species are able to coexist in the same range. They even found that in most interactions, Golden Eagles were dominant, and in direct competition would come out on top (Fig. 1; Halley, 1998).

SUPPORT FROM THE PUBLIC

The reintroduction of White-tailed Eagles to the Isle of Wight is now well under way, with two pairs on the south coast showing signs of being territorial and exhibiting signs of pair bonding (Dennis, 2023). There has also been negative feedback from local farmers. One claimed that the birds nearby had killed 180 of his lambs. He states "The birds that have proven to be a problem have to be removed." (Mcintyre, 2019). Nevertheless, support from the wider public for the project on the Isle of Wight has been very large, with 90% of responses from both local people and people from the surrounding area submitting that they are in support of the reintroduction (Fig. 2; Dunn, 2022). They also looked at the ecotourism benefits that the White-tailed Eagles could have, asking people if they were more likely, less likely to visit, or unaware of the project. More than 70% of the results indicated that they would be more likely to visit the Isle of Wight since the reintroduction, which would no doubt bring an economic benefit to the island (Fig. 3; Dunn, 2022). Evidence from Scotland shows that eagle tourism can be very popular, and this could be great for the Isle of Wight's economy, especially in winter (Dennis, 2023). The reintroduction is already having this effect at Poole Harbour, which has recently become a hotspot to view the White-tailed Eagles from the Isle of Wight reintroduction. Birds of Poole Harbour boat tours take customers around the harbour to show people the birds found there. A ticket for one of these boat safaris costs £25 for an adult and £12.50 for a child, and these boat trips are often sold out. (Birds of Poole Harbour, 2023).

In Norfolk, there was a plan to release 60 White-tailed Eagles at Wild Ken Hill.However, the project was cancelled due to objections from local landowners due to fears that the birds would feed on their livestock (Ashworth, 2021), despite the outstanding positive public support for the project on the Isle of Wight.

POSSIBLE HUMAN-WILDLIFE CONFLICT SOLUTIONS

Farmers in the south of the UK have no compensation that will pay them for lambs killed by White-tailed Eagles. Putting compensations in place would mean that less revenue would be lost by farmers when their lambs are thought to have been killed by the White-tailed Eagles. "None of the 120 or so farms and crofts in the scheme is paid compensation for their lamb losses." (Farmers Weekly, 2023).

In Norway, which has a population of 2,800–4,200

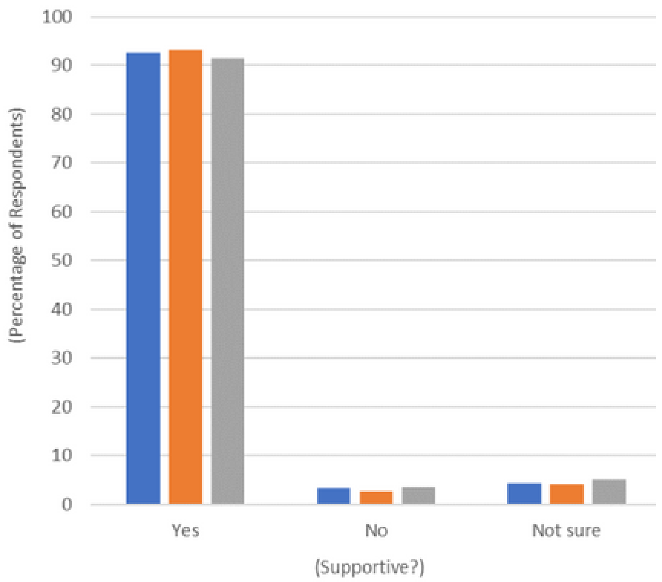

Figure 2 – These are the results of 'the favorability of the reintroduction from Isle of Wight residents and people in the surrounding area (Dunn, 2022). Blue are all respondents, orange are Isle of Wight residents and grey are Hampshire, Dorset and Sussex residents.

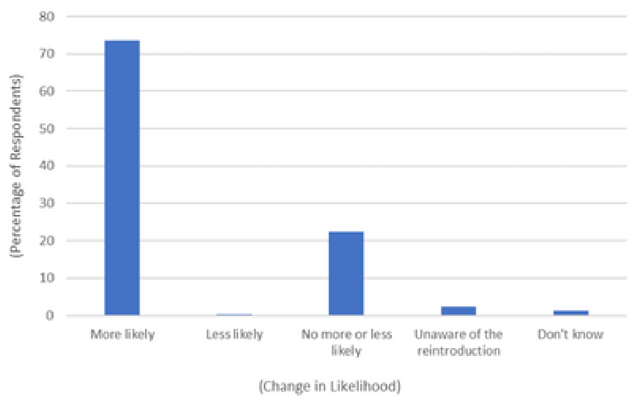

Figure 3 – Results from the change in likelihood of people to visit the Isle of Wight since finding out about the reintroduction (Dunn, 2022).

White-tailed Eagles (Eldegard *et al.*, 2020), sheep farmers seem to have fewer problems from predation of White-tailed Eagles on their sheep. During the 30-year carcass autopsy scheme carried out by Norwegian Nature Inspectorate on livestock, which were suspected of being killed by protected birds of prey, there has only been one case that was confirmed as a White-tailed Eagle attacking livestock (Birdlife, 2019). From this, we may be able to conclude that the population of White-tailed Eagles in the areas with more lamb predation is above the carrying capacity that the ecosystem is able to support, pushing the eagles to look for new sources of food such as farmer's livestock. Although it is thought that they mostly feed on stillborn/already dead lambs, it has been admitted by Scottish Natural Heritage that White Tailed Eagles do in some cases feed on healthy lambs, this was concluded from some work looking at remains in the Eagles nests done by the Scottish Natural Heritage (The Scottish Farmer, 2019).

To help farmers affected by White-tailed Eagles in Scotland, they have put in place a Sea Eagle Management Scheme (Scotland's Nature Agency, 2020). They have recruited 'call-off contractors' who investigate White-tailed Eagle activity and give advice on how to mitigate or deter the White-tailed Eagles away from their land. Farmers can borrow equipment for this and can be lent up to £1,500 per year for affected farmers to carry out agreed livestock management (Scotland's Nature Agency, 2020).

The conflict between these large birds of prey and sheep farmers is far from new, and can be a sensitive topic which can be difficult to find a compromise with. There is no method that has been discovered that can be used to resolve this issue, but there are ways of reducing the effects of White-tailed Eagle introductions on farmers. One method that could be put in place, and which is being used in other parts of Europe for predation by a range of species, is to compensate farmers for their losses.

In France there is a compensation scheme for predation by Wolves (*Canis lupus*) that have been colonising the country in recent years, attacking livestock in the process. By 2020, the French government had put in place €38 million, 90% of which was used for anti-wolf measures, and the other 10% used for compensation for the farmers' losses (INRAE, 2023). Although this was at a much larger scale, this provides the farmers with financial support, reducing the impact that the predation of their lambs has on their incomes.

Another method that some farmers in the UK have had some success with is the use of diversionary feeding under license. This involves providing an alternative food source for the White-tailed Eagles when the lambs are particularly vulnerable (Scotland's Nature Agency, 2020). Despite success in some farms, this method is not always successful. Another method of deterring White-tailed Eagles could be the use of scaring machines. These can use both noise and light. These have been tested by the Conservation agency of Scottish Natural Heritage, and it is said that lasers could be used to scare White-tailed Eagles from flocks of sheep (BBC, 2018)

Since the beginning of the White-tailed Eagle reintroduction on the Isle of Mull, at least seven White-tailed Eagles have been illegally killed, and four clutches of eggs have been stolen (RSPB, 2019). In the south of the UK, of the Isle of Wight birds, the RSPB are aware of three White-tailed Eagles that have been killed illegally in 2020/2021 (RSPB, 2023b). According to the BBC (2016), birds of prey are targeted to protect livestock and pets. There is a lack of knowledge from specific groups about these birds, their ecology and the role they play in the ecosystem.

CONCLUSION

There is no clear solution to resolve this conflict, but methods of reducing the impacts on farmers must be looked into to reduce the impacts of predation by White-tailed Eagles. These methods could include more investment of money into compensating the farmers for their losses, mitigating how deeply they are affected; deterring systems (noise or light); diversionary feeding; or giving advice on land management which could mitigate the effect of the birds. People have not lived among White-tailed Eagles in generations, so it can be difficult to be in close proximity to these apex predators. It is important to take into account the effect that the White-tailed Eagles can have on people's livelihoods, and their feedback must be taken seriously. More research is needed on the relationship between humans and the White-tailed Eagles. But with more aid for farmers, and more time for them to coexist, the problems between the White-tailed Eagles and farmers could be resolved.

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Is climate change the driving force behind the recent appearance of egrets in the United Kingdom?

Oliver Samuel Norris

ABSTRACT

It is commonly accepted that due to the effects of climate change many species of birds are expanding their ranges into colder climes as areas that were previously too cold for them are now becoming accessible. The Little Egret (*Egretta garzetta*), and more recently the Great White Egret (*Ardea alba*) and Cattle Egret (*Bubulcus ibis*), have started to appear in the UK in large populations for the first time in history with breeding populations in the former two species having started to develop. In this paper I have looked at the possible reasons for this increase and whether this increase is in any way linked to climate change. The evidence shows that climate change is indeed the main driving force behind the species' movement northwards. The evidence also suggests that if the climate had not been warming, then these birds would not have moved north and would have remained in their ranges across Continental Europe for the foreseeable future.

INTRODUCTION

Little Egrets (*Egretta garzetta*) and Great White Egrets (*Ardea alba*) have experienced a significant population increase in Continental Europe since the 1980s (Keller *et al.*, 2020), which has led firstly to the Little Egrets colonising the UK with the first breeding pair present on Brownsea Island in 1996 (Ogilvie *et al.*, 1999). Since then the population has expanded with 1,024 birds present in the UK currently (Austin *et al.*, 2023). This increase is now being mimicked by Great White Egrets (EuroBird Portal, 2023), which bred in the UK for the first time in 2010 (BTO, 2023) with 50 breeding pairs present in 2020 (Morgan *et al.*, 2020). Is the Great White Egret following the same pattern as the Little Egret did a decade before and if so, would this provide evidence that these birds are moving northwards to escape from the warmer temperatures present in Continental Europe?

All species of egrets are wetland habitat preferential and are monitored relatively successfully and thoroughly by the BTO/RSPB/JNCC Wetland Bird Survey (WeBS), which means that accurate data is available about the breeding and migratory patterns of these birds. During the colonisation of Little Egrets, the western side of the UK colonised much faster than the eastern side (WeBS, 2023). This is due to the large numbers of estuaries and other open bodies of water which provide plentiful amounts of food. Egrets primarily forage for food in areas of shallow water, which occasionally includes tidal creeks (Neil Calbrade pers comm). Examples of the types of habitats the egrets use to forage off of at low tide include the Severn Estuary and the Mersey Estuary.

The Little Egret has been present in the UK since 1826 when the first bird was recorded (Neil Calbrade pers comm). There is potential that the species was present prior to this recording date as there are some documents in the British Library from Crowland in Lincolnshire dated between 1588 and 1622 which state that at Dousdale Holt there are some "white herons" which are breeding there (Neil Calbrade, pers comm). But given that this was before scientific methods were widely used it is safe to assume that the first proper sighting was the one occurring in 1826. After this, the sightings of these birds were few and far between with often decades going past without a single sighting (Neil Calbrade pers comm). The number started to increase in the late 20th century (Musgrove, 2002) with a one-off, sudden

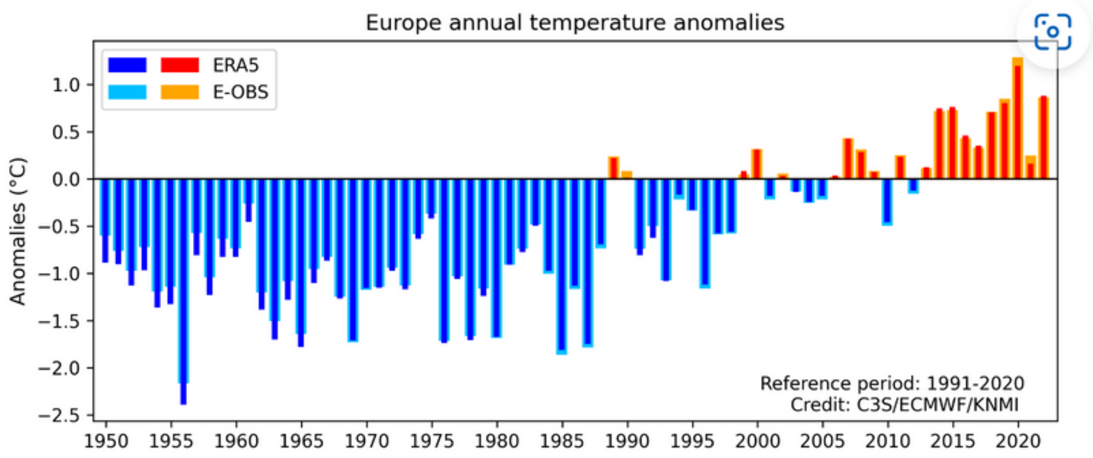

Figure 1 – Annual European land surface air temperature anomalies for 1950 to 2022, relative to the 1991–2020 reference period. Data source: ERA5 and EOBS (C3S/ECMWF/KNMI).

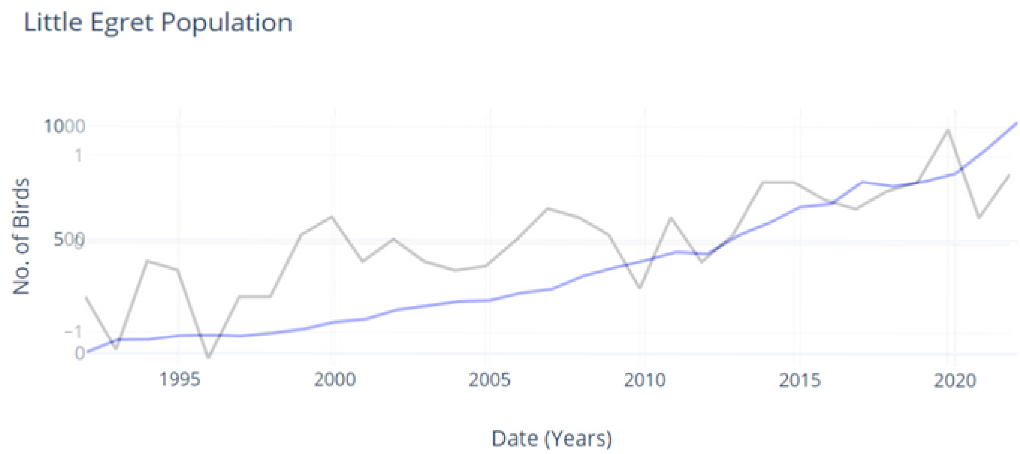

Figure 2 – Little Egret population numbers (WeBS, 2023) against climate data (Copernicus Climate Change Service, 2023). Number of birds is in blue and temperature is in grey.

influx of birds in 1970. When the birds came off of the British Birds Rarities Committee (BBRC) list and started being counted by the WeBS survey in 1993 (total stood at 58) the numbers were set to increase steadily over the following years. The species' upwards trajectory (Fig. 2) means it is highly likely that this population will continue to grow and increase in distribution over the next few years.

METHODS

My report questions what drove this change and caused mass migration north from the continent. The hypothesis this paper argues is that this change and move northwards is caused by climate change and the increase in the temperature on the continent is allowing the birds to access certain parts of Europe that were previously out of reach due to the temperature being too cold. To see if the migration of the birds northwards is in any way linked to temperature I looked at climate data (Copernicus Climate Change Service, 2023) to see if I could see any correlation between temperature and movement of Little Egrets into the UK. Population data for the Egrets was obtained through both the BBRC as well as the annual WeBS surveys.

RESULTS & DISCUSSION

The Copernicus Climate Change Service (2023) data shows a clear increase in temperature (Fig. 1) which we know is caused by climate change (IPCC, 2022), but does this increase correlate with the increase in Little Egrets in the UK? The first major influx in Little Egrets occurred in 1970 (Musgrove, 2002), which was a year in which average temperature anomalies were -1.6°C. Clearly, the climate data does not support the fact that that influx was caused by climate change. However, the next real increase in numbers that were

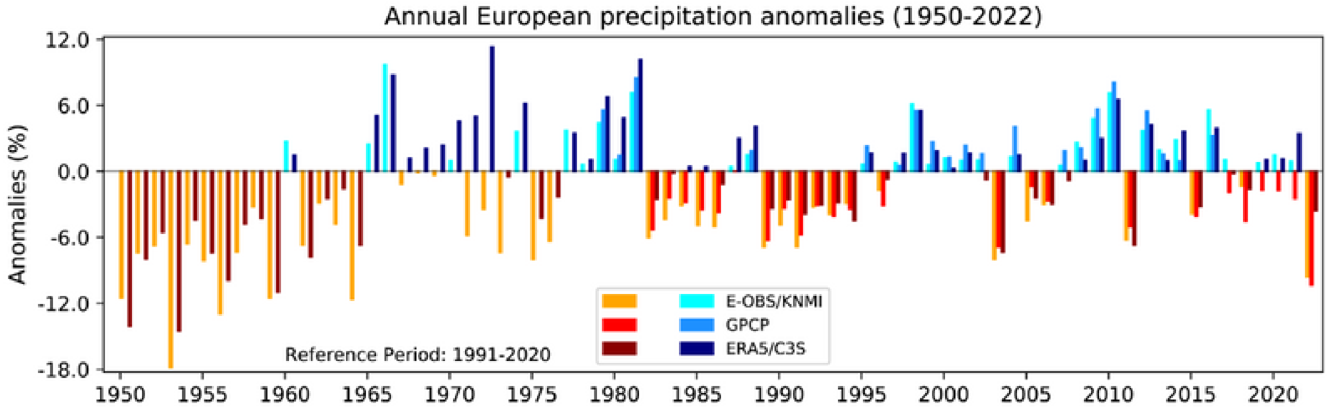

Figure 3 – Annual European precipitation anomalies (%) over land from 1950 to 2022. The anomalies are expressed as a percentage of the annual average for the 1991–2020 reference period. Data source: E-OBS[1] (light blue and orange, starting in 1950), GPCP (blue and red, starting in 1979), and ERA5 (dark blue and dark red, starting in 1950).

appearing in the UK was during the winter WeBS survey of 2001/2 when numbers reached 193 birds (Austin et al., 2023). According to the climate data, 2000 was the warmest year so far with temperature anomalies reaching 0.4°C and the following migratory season the Little Egret influx occurred. This could possibly prove the hypothesis but just looking at this one data point is inconclusive.

The overall trend in Fig. 2 shows that when the temperature increased so did the population of Little Egrets. This graph also demonstrates the fact that the increase in Little Egret populations was directly proportional to the temperature. For example, when the temperature decreased between 2009–2013 so did the population of Little Egrets in the UK. This would suggest that the hypothesis concerning climate change being the primary driver behind the movement of Little Egrets into the UK is correct as the egret numbers do follow the trend of the climate data.

1970 Population Influx

For the influx of 34 birds in 1970 (Musgrove, 2002), it must be established what the main causes of this sudden and sharp population increase were. It is clear to see that increased temperature was not the driving force behind the 1970 increase (Fig. 1). One of the commonly established reasons for sudden migrations is heavy rainfall or, conversely, drought.

When looking at the data on precipitation rates, it is clear that the precipitation rates for 1970 were considerably lower than the rates for the years around it, which could provide a reason for the migration of Little Egrets. However, when looking at the year 1970, it clearly shows that rainfall rates were very low, compared to a wider range of years (e.g. 1950–1965) where there was no notable influx of Little Egrets (Fig. 3–4).

There also seems to be no strong case for glacial ice masses or soil moisture having caused the 1970 influx as after having looked at data on both of these aspects (Copernicus Climate Change Service, 2023) no significant changes in either of these data sets occurred in 1970 and as such could not form possible reasons for the sudden influx of birds.

Conclusion for 1970 influx

Looking at all of the evidence it is clear that it is best that the 1970 influx is written off as an anomalous result as it does not fit with any trend, previous or yet to come, for decades in either

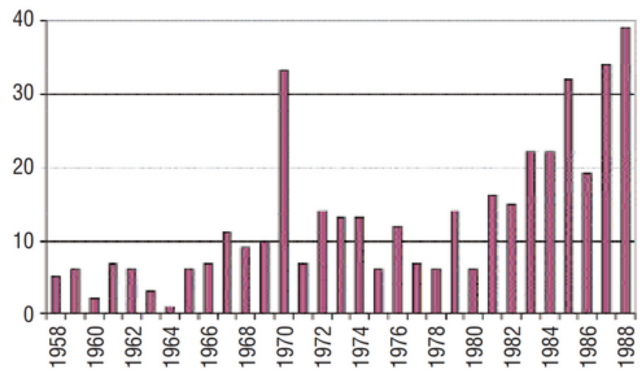

Figure 4. Breeding numbers of Little Egret in Britain. Adapted from Musgrove (2002).

direction. It is possible that the results obtained for this year are faulty as they are so contrary to all data that surrounds them for other years. This fault could well have arisen due to the fact that what were believed to be two different flocks at the time could well have actually been the same flock that had just relocated to a different place and hence leading to a mistaken double count. If this data was counted as being a double count for example those 34 birds would be more in the region of 17 birds, which seems to be a bit more feasible given that in 1971 the population of birds was 15 (Fig.4).

Potential extrapolation to other egret species

It remains to be seen if the trends that have been observed in the Little Egrets will be fully replicated in the Great White Egret, as the bird has not been present in the UK for long enough for the same accumulation of data to be present. However, it is possible to utilise the data that we do currently have on Great White Egrets and compare it with that which we have on Little Egrets and see if the trends can be replicated and hence work out if the same causal effects, namely climate change, are also affecting the Great White Egrets.

The first recorded sightings of Great White Egrets were in the 1960s where 11 were recorded in the gap between 1960–1979 (Ławicki, 2014). Since 1977 the species has been recorded almost annually. Looking at the graph of Great White Egret populations in blue and the temperature anomalies in grey (Fig. 5) it is clear to see that, whilst the Great White population started to increase much later on than the Little Egrets did, they have both clearly increased in numbers due to the results of climate change as they both follow the same upwards trend that mirrors the upwards trend of the temperature anomaly data. The principle difference between the two species is that whilst the Little Egret population increase was directly proportional to the temperature the Great White Egret increased in a much more consistent way, not responding as much to the individual year on year fluctuations. Despite this however it is still evident that the Great White Egret numbers are increasing due to the results of climate change just like the Little Egret did.

CONCLUSION

It is highly likely that climate change is the driving factor behind the movements of both species of Egrets. The warming of the climate in Continental Europe is forcing these birds to seek colder climes in which to spend their time and it is this which is bringing them to the UK and the reason that they have not, in the case of the Little Egret, stayed in the south of the country, but have moved northwards up into Scotland in their pursuit of colder weather systems (Neil Calbrade pers comm). We can only assume that given time the Great White Egrets will follow along given that in most other regards their movement patterns have mimicked one another. The movement pattern that is shown between the species is extremely close and it is likely that they will move up the country towards Scotland as the climate warms, sticking primarily to the western coast due to the

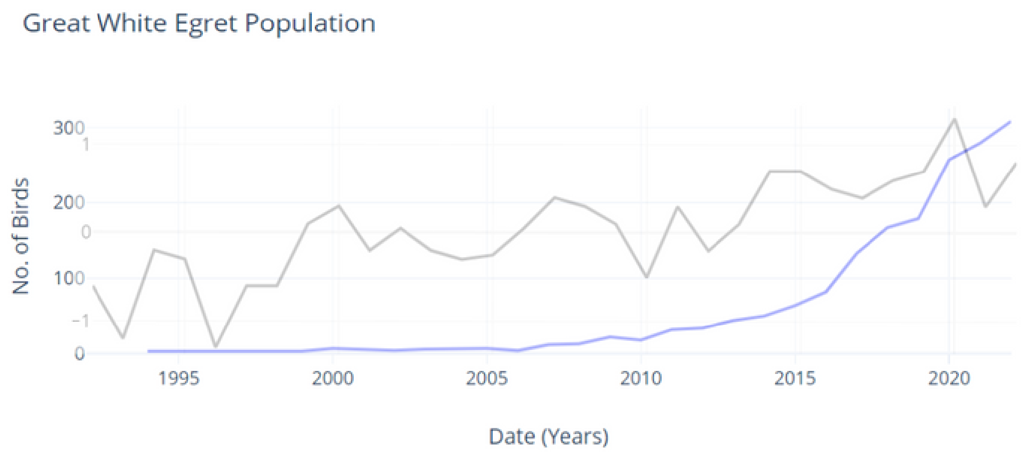

Figure 5 – Great White Egret population numbers (WeBS, 2023) against climate data (Copernicus Climate Change Service, 2023). Number of birds is in blue and temperature is in grey.

abundance of mudflats and estuaries that are found there

The only difference between the movement patterns of the two species is that the Great White Egrets tend to show a more consistent upwards trend than the Little Egrets, which did fluctuate depending on the relative temperature increase for that year. Fig. 2 shows that the movement of Little Egrets is directly proportional to the relative increase in temperature in a way that is not present in the Great White Egrets. These birds seem to be increasing at a consistent rate that does follow the overall trend of climate change (Fig. 5), but is not directly proportional to the relative temperature change on the continent for that year. It is likely that these birds are both being forced northwards because of one specific reason, that reason being climate change. If we could hypothetically reverse climate change and return to the temperatures seen before the mass migration of these species it is likely that we would see this movement trend northwards reversed and the birds that are currently present in the UK would move back south to their more historical ranges across Continental Europe.

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Analysis of the potential causes of Common Cuckoo (*Cuculus canorus*) decline in England

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ABSTRACT

Over the last few decades, the population of Cuckoos (*Cuculus canorus*) in England has decreased significantly. I examined the entire annual cycle of the Cuckoo to identify potential causes for decline at different stages. Reduced annual survival rate due to food availability and/or reduced productivity due to host species availability are the most likely causes of decline. I analysed available data on Cuckoo abundance, changing weather patterns, host species abundance, food species abundance, and tracking data show mortality rate at different points during migration. I found a higher mortality rate for the western route, particularly around the Iberian peninsula, to be the main factor contributing to the decline of British Cuckoos.

INTRODUCTION

The Cuckoo (Cuculus canorus) is a species of bird that breeds in Britain. It is also a widespread breeding visitor in Continental Europe. It is a Palearctic migrant, meaning it spends the winter in Africa and visits Eurasia in the summer to breed (BTO, 2023). The Cuckoo declined by 38% across the United Kingdom (UK) from 1994 to 2019, but this trend was not uniform across the UK. In England, there has been a 73% decline from 1994 to 2019, however, in Scotland there was a 78% increase for the same period (Harris *et al.*, 2022). It is important to understand the causes of the decline in order to help conservation efforts for this species.

Cuckoos spend the winter in the Congo basin, a tropical region near the equator in Africa (Hewson *et al.*, 2016). Cuckoos primarily feed on caterpillars. They move around following the rains and consequent outbreaks of caterpillars in Africa (Wyllie, 1981). This suggests that the position of the Intertropical Convergence Zone (ITCZ) is of great importance to the northward migration of Cuckoos in spring. There is evidence of Cuckoos migrating northward in Nigeria during March and April, and then reaching the strait of Gibraltar in the second half of April (Payne, 1938; Smith, 1968). The main arrival of Cuckoos in the UK occurs from mid-late April (De Smet, 1970). This is similar timing to most other Palearctic migrants, however, adult Cuckoos leave the UK in July, which is earlier than most other breeding visitors (Wyllie, 1981). During the southward migration, Cuckoos from Britain either take a southwestern route via Spain, or a southeastern route via Italy. According to tracking data, birds that migrated through Spain had a higher mortality rate than those that migrated through Italy (BTO, 2023). This suggests that conditions in Spain are less favourable to Cuckoos. In summer the ITCZ moves north and brings rain over the Sahel region in Africa (Furman, 2023). This brings high rainfall to this region, which results in a high abundance of caterpillars. Reaching the Sahel in time to exploit the food resources brought by the rains is a potential benefit of an early post-breeding migration (Wyllie, 1981). After passing through the Sahel region the Cuckoos' final destination is the Congo Basin (BTO, 2023).

The objective of this paper is to examine the entire annual cycle of Cuckoos and to identify any potential causes of decline. This may help conservation efforts in the future become more targeted and therefore, more effective.

METHODS

This report investigated four potential causes of decline in UK populations of Cuckoo: (1) unfavourable weather conditions on the Spanish route for autumn migration, (2) reduced rainfall in the Sahel region, (3) earlier breeding onset for species that the Cuckoo parasitises, and (4) reductions in the populations of macro-moths in Britain. Firstly, I examined potential causes of decline related to the autumn migration. I looked at BTO tracking data (Hewson *et al.*, 2016) to see if there was a difference in mortality rate between Cuckoos taking the western migration route and the eastern migration route. I then compared data on the mean summer rainfall (June-August) in Spain and Italy (Statista, 2018; 2023).

After this, I investigated a potential cause for decline found in both the spring and autumn migrations. I looked at trends in rainfall in the Sahel region (Seidl, 2008) and compared them to the Cuckoo population in England (Massimino et al., 2022). Then I looked into potential causes for decline found at the breeding grounds. I investigated whether the Cuckoo decline could be linked to the declines or changes in breeding dates of host species. The most important host species in the UK are Dunnock (*Prunella modularis)*, Reed Warbler (*Acrocephalus scirpaceus*) and Meadow Pipit (*Anthus pratensis)* and Pied Wagtail (*Motacilla alba*) (Douglas *et al.*, 2010). I looked at BTO data from the BBS and NRS (Massimino *et al.*, 2022) to see if any of these species had changed in population size or the start date of breeding.

Lastly, I used the BTO data from the CBC and BBS (Massimino *et al.*, 2022) and calculated a percentage change in Cuckoo abundance in England from 1968–2017 (using the smoothed population index) and looked for a correlation with the percentage change in 'larger moth' abundance in southern Britain from 1968–2017 (Butterfly Conservation Trust, 2021).

RESULTS

BTO tracking data shows that there is a higher mortality rate for Cuckoos that take the western migration route, via Spain, compared to those that take the eastern migration route, via Italy (Fig. 1; Hewson *et al.*, 2016). Weather data from Spain

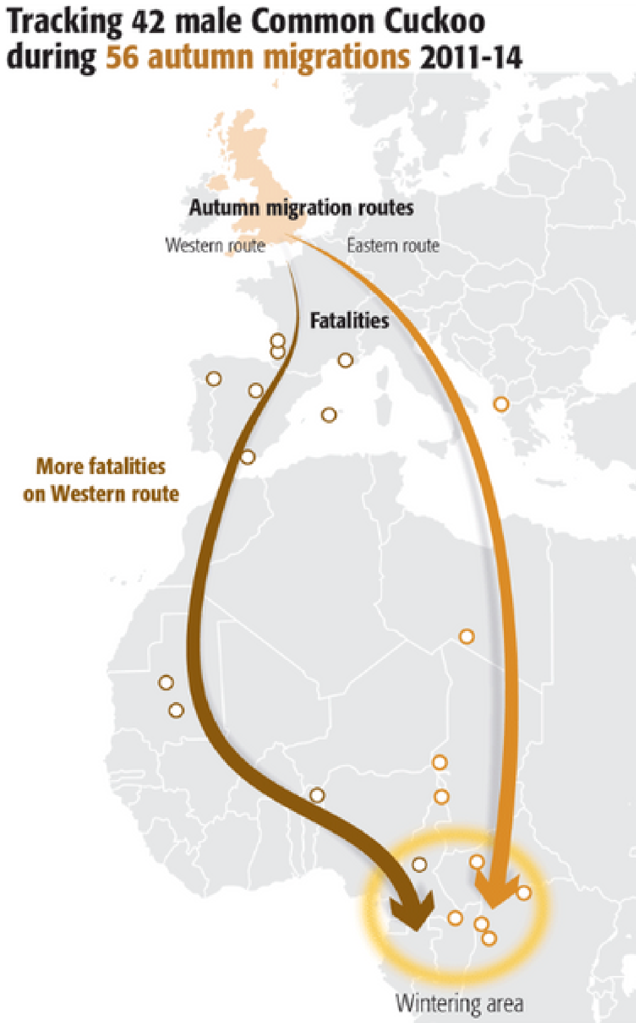

Figure 1 – Tracking data from the BTO's Cuckoo project (2011), showing the autumn migration routes taken by Cuckoos and the fatalities recorded on each route from 2011–2014 (BTO, 2023; infographic by Nigel Hawtin).

and Italy shows that there is a difference in average summer precipitation across the entire country. From 1997–2017 the mean summer rainfall in Italy was 183mm (Statista, 2018). From 2015–2022 the mean summer rainfall in Spain was 70mm (Statista, 2023). This difference is important because Cuckoos rely on the caterpillars of large moths as their main food source. High rainfall results in an increase of fresh plant material, which may lead to an increase in caterpillar abundance. On average, Spain only receives 38% as much summer rainfall as Italy.

The Sahel rainfall index decreased from approximately +1.8cm/month in 1966 to -1.5cm/month in 1985. It then increased back up to +1.3cm/year by 2016 (Seidl, 2008). From 1966 to 1985 the Cuckoo abundance in England changed

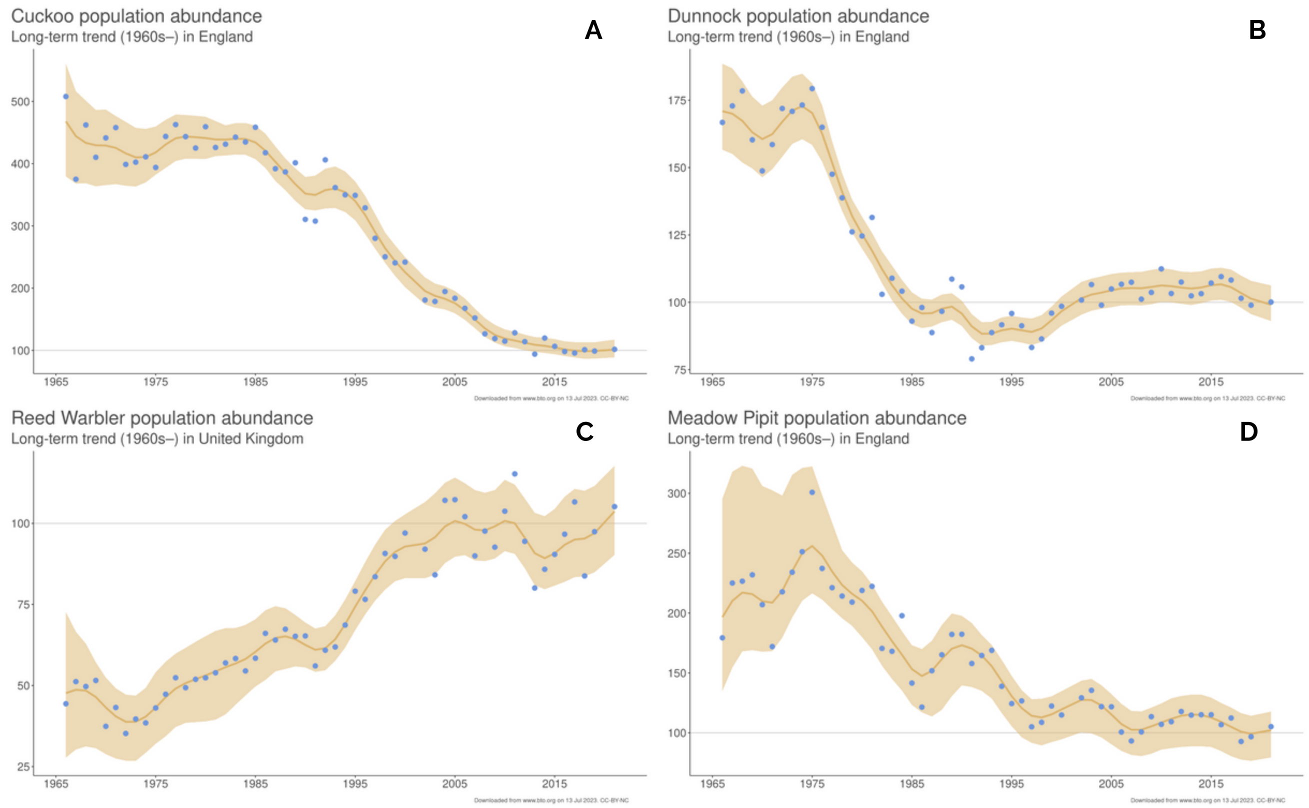

Figure 2 – The change in population abundance from 1966-2021 for Cuckoo (A), Dunnock (B), Reed Warbler (C) and Meadow Pipit (D) (BTO, 2023).

by -7%. From 1985 to 2016, the Cuckoo abundance in England changed by -77%. (Massimino *et al.*, 2022). Dunnock abundance in England showed a sharp decline of 42% from 1975 to 1985. During this time Cuckoo abundance increased by 4%. From 1985 to 2019 there was a very small increase in Dunnock abundance of 4%. During this time Cuckoo abundance decreased by 77%. Reed Warbler abundance in England increased by 80%, and during this time Cuckoo abundance decreased by 79%. From 1966 to 2019 the abundance of Meadow Pipits in England decreased by 50%, during this time Cuckoo abundance decreased by 79%. (Fig. 2; Massimino *et al.*, 2022). From 1994 to 2019 the Meadow Pipit abundance in Scotland decreased by 11% and the Cuckoo abundance increased by 78% (Harris *et al.*, 2022).

The overall trend in 'larger moth' abundance from 1968–2017 was -39% in southern Britain (Fig. 3; Butterfly Conservation Trust, 2021). The change in Cuckoo abundance from 1968–2017 was -77% (Massimino *et al.*, 2022). This shows that there could be a positive correlation between Cuckoo

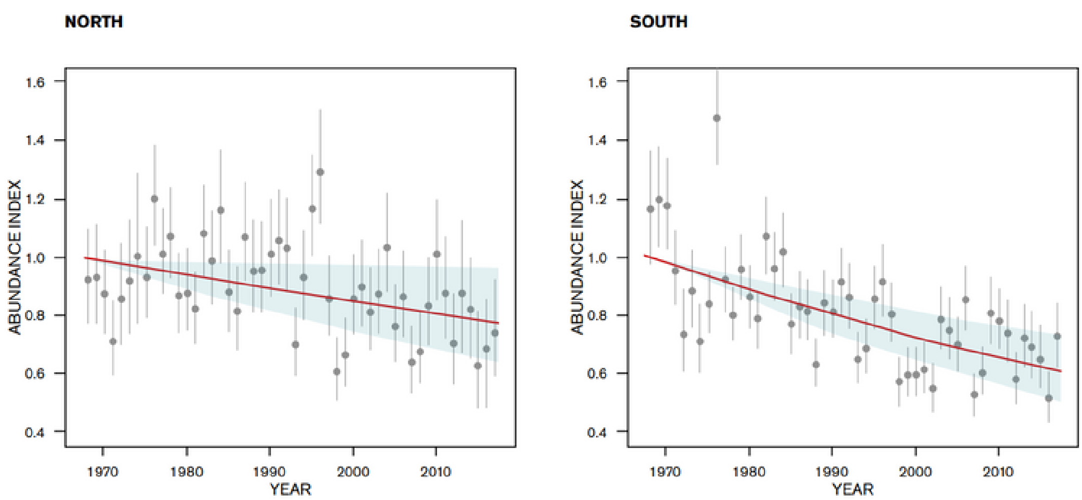

Figure 3 – Showing the relative abundance of 'larger moths' from 1968–2017 in northern Britain and southern Britain (Butterfly Conservation Trust, 2021).

abundance and large moth abundance. The overall trend in large moth abundance in northern Britain from 1968–2017 was -4.4% per decade (Fig. 3; Butterfly Conservation Trust, 2021), but the trend in Cuckoo abundance in Scotland from 1994-2017 was +30% (Massimino *et al.*, 2022).

DISCUSSION

The low levels of summer rainfall in Spain could result in reduced abundance of large caterpillars in Spain compared to Italy. This will result in reduced annual survival rate of Cuckoos. The tracking data shows there is a higher mortality rate for Cuckoos taking the Spanish route compared to the Italian route (BTO, 2023). This suggests that summer droughts in Spain are a significant contribution to Cuckoo decline.

Cuckoos move around following the rains and consequent outbreaks of caterpillars in Africa (Wyllie, 1981). A decrease in annual rainfall in the Sahel could be a potential cause for Cuckoo decline, as it would decrease caterpillar abundance and therefore decrease annual survival rate. Despite this, the data shows that Cuckoo abundance decreased faster whilst rainfall levels in the Sahel were increasing. This result suggests that Sahel rainfall is not the primary cause of Cuckoo decline. If it was the primary factor, there would be a positive correlation between the Sahel rainfall index and Cuckoo abundance.

A decrease in the populations of host species could result in a decrease in productivity for Cuckoos and potentially cause a decline. There does not appear to be a positive correlation between Cuckoo abundance and Dunnock (1975–2022) or Reed Warbler (1966–2019) abundance in England There is a positive correlation between the abundance of Cuckoos and Meadow Pipits in England from 1966–2019. A study in Devon has shown that Cuckoos are more likely to be detected in habitats with more Meadow Pipits and fewer Dunnocks (Denerley *et al.*, 2018). Another study suggests that Cuckoos have shifted their preference from Dunnocks to Reed Warblers and Meadow Pipits as their host species (Douglas *et al.*, 2010). This suggests that Meadow Pipits are more important than Dunnocks as a host species and could potentially be why the Meadow Pipit population trends appear to be more closely correlated with Cuckoo population trends.

Due to a heavy reliance on the ITCZ, the Cuckoo has little ability to change the dates of its spring migration. However, due to increasing annual temperatures in the UK caused by climate change, host species have begun breeding slightly earlier. Douglas *et al.* (2010) showed that Dunnock, Reed Warbler and Pied Wagtail had a six-day advancement in laying date from 1994–2007. Meadow Pipits did not show a significant change in laying date. Reed Warblers breed later than Dunnocks. This evidence, combined with the increase in abundance, has led to more Reed Warbler nests and fewer Dunnock nests available for Cuckoos. This explains the shift from Dunnocks to Reed Warblers and Meadow Pipits as host species.

Nationally, Cuckoos have been shown to become more associated with upland heath, characterised by the presence of Meadow Pipit hosts (Denerley *et al.*, 2018). However, there is a negative correlation between Cuckoo and Meadow Pipit abundance in Scotland from 1994–2019. This casts doubt over whether the decline in Cuckoos is related to Meadow Pipit decline. Furthermore, it seems clear that there is not a strong positive correlation between Cuckoo and Dunnock or Reed Warbler population trends. This suggests that a change in abundance or breeding dates of host species is not the primary cause for decline in Cuckoos.

The caterpillars of large moths are the primary food source for adult Cuckoos, so a decline in the population of larger moths in the UK could reduce the annual adult survival rate of Cuckoos. A decrease in large moth abundance in northern Britain would be expected to cause a decrease in Cuckoo abundance in Scotland, however Cuckoo abundance increased during this time period. This suggests that large moth abundance is not the primary cause for the Cuckoo decline in England.

CONCLUSION

Cuckoo decline appears to be most closely linked to a high mortality rate for birds that take the western migration route. A potential cause for this is lower average rainfall levels in Spain that result in reduced food availability. Cuckoo decline does not appear to be closely related to changes in rainfall in the Sahel region, host availability, or large moth abundance at the breeding grounds.

More extensive research into the causes behind a high mortality rate for Cuckoos on the western route is needed. In order to properly conserve this species we need to make changes that will reduce the mortality rate on this particular route.

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BTO JOURNAL OF
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